

Heatmap Evaluation of Facial Hydration Using a Novel Python Program

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ABSTRACT

Background: Evaluating cleansers and moisturizers provides important information to guide clinicians in the recommendation of these products. This project was performed to visualize skin hydration via heatmap after the use of a gentle skin cleanser (GSC) and moisturizing lotion (ML).

Methods: Half-face, intra-individual open-label study in healthy volunteers. Cleanser was administered in a single application that was then wiped off the face. Moisturizing lotion was applied at least once-daily for one week. Hydration measurements were made at 30 pre-defined points on half of the face, at baseline, and 30 minutes post-application; an additional assessment at week 1 was made for the moisturizing lotion. Heatmaps were generated using Python programming software to interpolate hydration values to colors that were then superimposed onto the volunteer's facial image.

Results: Five subjects completed the cleanser assessments, and 5 subjects completed the 30-minute evaluation for the lotion, with 4 completing the week 1 assessment. There was a visible shift in skin hydration post-GSC application from values approximately in the 12-42 AU (arbitrary unit) range to 30-60 AU at 30 minutes. Similarly, there was a shift in hydration from baseline to 30 minutes that continued to increase through week 1 of ML use.

Conclusions: This innovative heatmap data generation showed a clear, visual change in hydration over time. There was a visible shift in hydration values from baseline to 30 minutes after application of cleanser; hydration also improved after use of moisturizing lotion at 30 minutes and increased after week 1 application.

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INTRODUCTION

Understanding the hydration of facial skin poses a challenge in part because the skin is exposed to environmental humidity, sunlight, and pollution, which can impact water loss.¹ Traditionally, skin hydration is presented as data (charts, numbers); but for both consumers and healthcare professionals these data may be difficult to grasp intuitively. In addition, hydration assessed at a single location may under- or over-estimate hydration in other sites.^{1,2} Further, facial skin has increased water loss compared with other body sites, along with lower levels of ceramides and natural moisturizing factors.¹ Heatmapping is a technique to visualize skin hydration in real-life conditions.^{1,2} Facial mapping of multiple sites of skin capacitance helps visualize the moisture within the skin in 2-dimensional color maps that are then superimposed onto digital images.²

The primary function of the epidermis is to create a permeability barrier around the body to protect against the external environment.³ The stratum corneum (SC), the outermost layer of the epidermis, largely controls skin barrier function.⁴ When skin is healthy, the SC provides an efficient transport barrier while being soft, strong, and pliable enough to respond to physical strain and stress.⁴ Water content is one of the major factors that

control SC flexibility and skin hydration (the water content in cells) occurs primarily via the uptake of water by corneocytes.^{4,5} Skin cells are embedded in a lipid-rich intercellular matrix, which confers waterproof properties.⁵ The interplay of these factors maintains barrier function and control of transepidermal water loss (TEWL) even in a dry environment.^{4,5} Poor skin hydration leads to dry, itchy, uncomfortable skin and even diseases such as eczema.⁵ Well-hydrated skin is supple and protects against skin cracking or fissuring.⁶

Cleansing skin removes dirt, oil, and bacteria from the skin surface and washes away dead cells.⁷ While cleansing alone does not maintain skin hydration, it is an important aspect of skin health. Gentle cleansers that do not compromise the skin barrier or result in compensatory sebum production or other undesired effects should be recommended to all dermatology patients.⁷ Moisturizing reduces the evaporation of water from the skin, minimizing TEWL.⁵ Hydration of the skin results in a smooth and soft texture as well as a younger seeming complexion.^{8,9} This study was designed to assess the moisturizing effect of a gentle skin cleanser (GSC) and moisturizing lotion (ML) with the hydrating ingredients glycerin, panthenol, and niacinamide.

MATERIALS AND METHODS

This was a half-face, intra-individual open-label study conducted on healthy volunteers to visualize the level of skin hydration via heatmap. Subjects applied a gentle skin cleanser (GSC) and moisturizing lotion (ML) to the whole face (both Cetaphil, Galderma, Dallas, TX) and assessments were performed on half of the face. GSC was administered in a single application that was then wiped off the face. Moisturizing lotion was applied at least once daily for one week. Facial digital images were captured by VISIA-CR (Canfield Scientific, Inc., NJ, USA). Hydration measurements were made by using a Corneometer (Courage + Khazaka electronic GmbH, Germany) at 30 pre-defined points on half of the face, at baseline, and at 30 minutes post-application; an additional assessment at one week was made for ML (Figure 1).^{1,2}

Heatmaps were generated using the PyCharm algorithm, a Python programming software (JetBrains, Prague, Czech Republic), to interpolate hydration values to colors that were then superimposed onto the subject's facial image. Adobe Illustrator and Photoshop (Adobe Inc, CA, USA) were used to blend colors into a gradient heatmap. A rainbow color scale was applied with green-blue hues associated with the degree

FIGURE 1. Points of hydration measurement. From Voegeli et al, with permission.¹

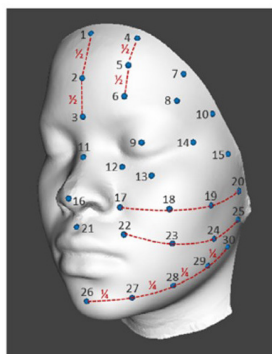


TABLE 1.

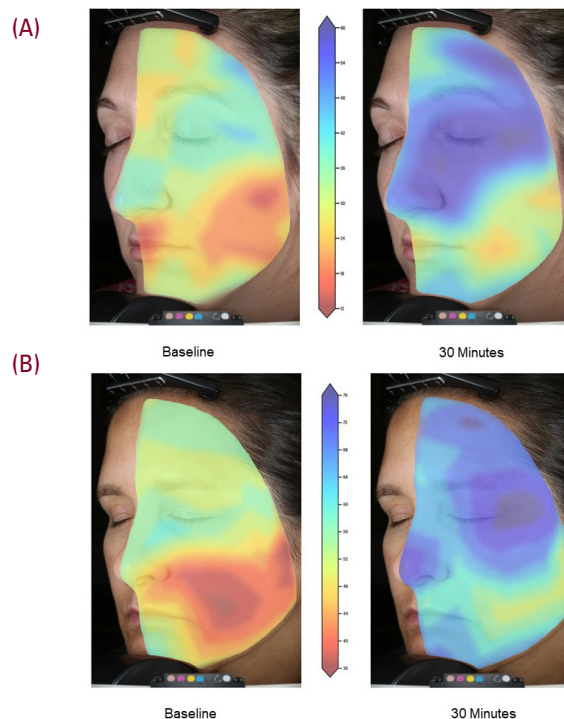
Subject Demographics			
Characteristic	Category	N (Gentle Skin Cleanser)	N (Moisturizing Lotion)
Gender	Female	5	5
Race	Caucasian	5	5
Fitzpatrick Skin Type			
	I	0	1
	II	2	1
	III	3	3
Skin Type			
	Combination	4	0
	Oily	1	0
	Dry	0	3
	Normal	0	2

of hydration (relatively high hydration) and yellow-red hues associated with the degree of dryness (relatively low moisture content).

RESULTS

A total of 5 subjects completed the cleanser (GSC) assessments, and 5 subjects completed the 30-minute evaluation for the lotion (ML) with 4 completing the week 1 assessment. Subject demographics are presented in Table 1. There was a visible shift in skin hydration post-GSC application from values approximately in the 12-42 AU (arbitrary unit) range to 30-60 AU at 30 minutes (Figure 2).

FIGURE 2. Change in heatmap indicating higher moisture content at 30 minutes post-application of gentle skin cleanser. (A) Heatmap generated from individual results, and (B) Heatmap generated from average hydration results from all 5 subjects.¹

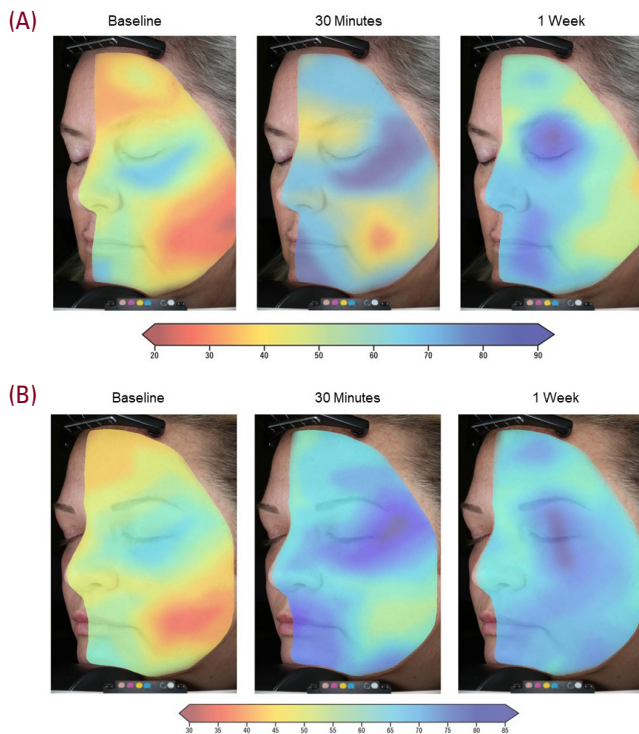


Similarly, the moisture maps demonstrate a shift in hydration from baseline to 30 minutes that continued to increase through week 1 of ML use (Figure 3). The visible change was appreciated in both individual hydration results and results averaged from the 5 participants.

DISCUSSION

Two-dimensional heatmaps are a useful tool to visualize skin hydration of the entire face. Changes in hydration before and after product application were demonstrated for GSC at 30 minutes after cleansing and for ML at 30 minutes and after 7 days of moisturizer use. This indicates a rapid and sustained hydration-boosting effect via clear color shifts. Not only is a

FIGURE 3. Change in heatmap indicating higher moisture content after use of moisturizing lotion. (A) Heatmap generated from individual results at 30 minutes post-application and week 1, (B) Heatmap generated from average hydration results from all subjects at 30 minutes post-application and week 1.



color visualization more readily appreciated intuitively when compared with numbers, charts, and graphs, but heatmaps also provide data about a larger area of skin than other methods (for example, using a probe to assess TEWL). Being able to assess skin hydration is directly relevant for understanding skin health and for following the effects of skincare as well as treatments on skin moisture.¹⁰ Heatmaps visibly demonstrate the variations in skin hydration, mirroring physiological differences in the biochemistry and cell biology of the stratum corneum – including skin thickness, lipid levels, levels of natural moisturizing factor, and corneocyte maturation status.¹⁰ In addition, Voegeli et al were able to show ethnic differences in hydration gradients with Black Africans having greater hydration than Indians, followed by Caucasians and Chinese – knowledge of these differences may translate to individualized management approaches.²

When recommending or selecting skincare products to optimize skin hydration, there are many considerations. Moisturizers have a wide variety of ingredients; actives such as glycerin, panthenol, and niacinamide can enhance their performance. Glycerin is a low molecular weight humectant that penetrates well into the stratum corneum to increase hydration.¹¹ Use of glycerin-containing moisturizers has been shown to soothe dry skin and reduce water loss in patients with atopic, dry, and irritated skin.¹²⁻¹⁴ Panthenol has humectant properties but is also

soothing, a quality that is important for individuals with sensitive skin. Niacinamide can improve skin barrier function while also providing beneficial effects on skin tone and pigmentation.^{15,16} Finally, it is important to select moisturizers with ingredients that enhance hydration but do not have irritation or allergic potential (alpha hydroxy acids, propylene glycol, and lanolin may cause irritation and allergic reactions).¹¹

Adequate hydration is essential to healthy functioning skin. With the proliferation of products available in the marketplace, it is important to select skincare regimens that have clear, effective results in achieving beneficial effects like hydration. In addition, in day-to-day clinical practice, healthcare professionals can use color maps to understand hydration data better and re-emphasize to patients the impact of good skincare on overall moisturization. As discussed above, lack of moisturization can lead to signs of skin aging such as dryness and the appearance of fine lines.

DISCLOSURES

Dr Nguyen, Dr Emesiani and Dr Meckfessel are employees of Galderma Laboratories, LP, Dallas, TX.

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